

NOTES ON *UROMYCES AMYGDALI*, COOKE : A
SYNONYM OF *PUCCINIA PRUNI*, PERS.
(PRUNE RUST).

BY D. McALPINE.

(Communicated by J. H. Maiden.)

(Plates xxxi., lower division, xxxii. and xxxiii.)

I have purposely placed the synonym first, because the fungus which it represents is still considered by Dr. Cooke, one of the authors of the name, a new one, and it will be part of the object of this paper to show that the Australian species thus named in Dr. Cooke's "Handbook" is really the same as that described by Persoon in his "Synopsis Methodica Fungorum" towards the end of last century.

This leaf-rust is of great economic importance, since it attacks such valuable fruit trees as the peach and nectarine, plum and apricot, cherry and almond, causing them prematurely to shed their leaves, and, as a consequence, either to bear no fruit or only small quantities of an inferior kind. As the peach-tree forms its fruit on the previous season's wood, it is evident that the succeeding crop will be affected as well, hence it is highly desirable to know the true nature and the right affinities of this fungus, thereby to be the better able to follow its life-history and to prevent its further spread.

HISTORY OF NAME.

The Australian fungus to which Dr. Cooke assigned the name of *Uromyces amygdali* was collected by H. Tryon, Government Entomologist of Queensland, in February, 1886, on peach and almond leaves, and forwarded almost immediately to Dr. Cooke for identification. As indicated in his "Handbook of Australian Fungi," this name had previously been used by him in Ravenel's "Fungi Americani Exsiccati," issued between 1878 and 1882.

The same name had also been used by Passerini in his "Erb. Critt. Ital." issued in 1873, and Cooke regards this fungus as identical with the one named by him. However, Passerini* subsequently in 1887, on further consideration, pronounced this to be the stilbospore condition of *Puccinia pruni*, Pers. This name of *Uromyces amygdali* is now being used in the different Colonies, having such a high authority at the back of it, but as we shall presently see, it is a misnomer, or rather a synonym of *Puccinia pruni*, Pers., as already decided by Passerini.

Puccinia pruni-spinosae was first employed by Persoon in his "Synopsis Methodica Fungorum," published in 1797, the specific name being derived from the host-plant, *Prunus spinosa* or black-thorn, but as the fungus is now known to have different hosts belonging to the genus *Prunus*, the *spinosa* is dropped as a matter of convenience.

Next, Link in his "Species Fungorum," published in 1825, named the same fungus *Puccinia prunorum*. *Uromyces prunorum*, Lk., var. *amygdali*, Vize, was applied by J. E. Vize† to a Californian specimen on peach leaves in 1878, and the same name was used by the Rev. C. Kalchbrenner‡ for a fungus on peach leaves from Caffraria in 1882. Next, in 1883, Dr. Cooke§ recorded *Puccinia prunorum*, Lk., for Victoria, then in 1886 *Uromyces amygdali*, Cooke, for Queensland, and finally in his "Handbook of Australian Fungi" for Queensland, Victoria and New South Wales on peach and almond leaves in 1892. It was suggested in Tryon's "Report on Insect and Fungus Pests"|| that this fungus belonged to *Puccinia pruni*, but Dr. Cooke repudiates the suggestion in the "Handbook," and with dogged determination sticks to his point in the following note: "We decline to accept this as agreeing with any form of *Puccinia pruni* with which it is commonly associated."

* Nuovo Giornale Botanico Italiano. Vol. x. p. 255, 1887.

† Grevillea, Vol. vii. p. 12, 1878.

‡ Ibid. Vol. xi. p. 19, 1882.

§ Ibid. Vol. xii. p. 97, 1883.

|| p. 98, 1889.

In order to make sure that we were dealing with the same fungus, I have examined peach leaves with the fungus named by Cooke himself in the Herbarium of the Government Botanist, and there is no doubt as to the identity of the specimens. Further, Mr. Tryon has very courteously sent me specimens of peach leaves similar to those formerly submitted to Dr. Cooke, and on which the name was based, with this important difference, however, that the original specimens were collected in February, while these are dated June.

In addition to this, specimens on peach, plum, apricot and almond leaves had been sent from South Australia to the United States Division of Vegetable Pathology, and it was reported in the *Journal of Mycology* for 1890 that these specimens agree in every particular with those of *Puccinia pruni*, Pers., on peach and plum hosts in the United States, nevertheless his own name was still retained by Dr. Cooke.

As the leaf-rust is unfortunately becoming, or rather has become, very prevalent and a very serious pest to the fruit-grower, it is at least advisable to agree upon some common name, to have uniformity of nomenclature in the different Colonies, so that when dealing with it therapeutically we may be agreed as to the cause of the disease dealt with. And not only so, but the name here has an important bearing when it enables us to recognise the useful fact that the rust in our orchards and the rust in our wheat-fields are but different species of the same genus (*Puccinia*), and that whatever prevents the disease in the one case is likely to be efficient in the other.

A further necessity exists for accurate scientific determination of this fungus from the fact that it is very commonly called "Peach Yellows" on account of the yellow blotches or freckles on the upper surface of the leaf, but it has no connection with the dreaded American disease so-called, which is believed to be, after years of investigation, due to Bacteria.

In the plum the spots assume a much darker colour, and the numerous pustules on the undersurface of the leaf sometimes give it the appearance of being coated with brown mud.

FIRST APPEARANCE IN THE COLONIES.

It is interesting and useful to trace the first appearance of any disease in our midst, to serve as a lesson for the future. Since 1891, when my first report was made upon it, this disease of the peach and allied trees has been constantly under notice. In certain fruit-growing districts it was only observed during season 1890-91 for the first time, but Mr. Neilson, of the Royal Horticultural Gardens, Burnley, informs me that the disease was observed there about 1887, and he had heard of it in the Fern-tree Gully district about 1885 or 1886. In the season of 1887-88 it was also reported for New South Wales, and in season 1889-90 it affected a large number of peach trees there, as stated in Dr. Cobb's article upon it in Ag. Gaz. N.S.W. Vol. i. Pt. 1, 1890, and the disease has been spreading ever since.

I am informed by Mr. Molineux, F.L.S., Secretary to the Agricultural Bureau of South Australia, that the first public reference to this disease was made by the late Frazer Crawford during May, 1890, in the "Garden and Field," as having been observed for the *first time* on peach trees, and he had little doubt that it occurred some time before, but on plum trees. The reference in Garden and Field, Vol. xv. p. 134, 1890, is worthy of quotation:—"This season for the first time I observed it (*i.e.*, *Puccinia pruni*) on a peach tree—or at least what I take to be the same fungus. The lower two-thirds of a large Peach tree has every leaf spotted by it, and as they are very numerous and bright yellow they give a variegated appearance to the foliage. . . . Strange to say, in a neighbour's garden, which has a number of plum trees all more or less attacked, there are a couple of peach trees untouched."

It is also present in Tasmania, although Mr. Thompson, the Govt. Entomologist,* does not refer to its first appearance there, and Mr. Tryon's discovery of it in Queensland in February, 1886, is undoubtedly the first definite record of its appearance in the Colonies.

* A Handbook to the Insect Pests of Farm and Orchard. Depart. of Agriculture, Tasmania, Bull. i. p. 29, 1892.

It is highly probable that the disease has been with us for some time and gradually gaining ground before attracting attention to its cause, for I have even known its effects to be confounded with the tints of autumn, and this seemed all the more plausible as it is usually associated with the shedding of the leaves.

TIME OF OCCURRENCE.

The time of appearance varies in different seasons, and the later it is the less damage it does. It also varies in its virulence according to the nature of the season. Thus in the Royal Horticultural Gardens the attack was very mild in 1888-89, then very bad in 1889-90, not very bad in 1890-91, and speaking for the Colony generally the past season was favourable to its spread. A grower in the Goulburn Valley writes :—"This season (1894-95) owing no doubt to the continued rains of the spring and the very heavy downpour in January, the attacks of this fungus have been very serious, causing a very large proportion of the leaves of the peaches to fall prematurely. Many acres of trees were thus laid bare for about 18 inches from the crown, only the younger wood surviving, and as a consequence nearly all the fruit for the coming season must come from near the top. Plums and prunes suffered severely, many trees being completely denuded of foliage by March." Thus, the disease seems to be intermittent in its character according to the prevailing weather. The following table shows the rainfall for the critical months :—

	Average for 1888. over 30 years.		1889. Average.		1890. Average.	
November	0·62 in.	2·50 in.	4·27 in.	2·48 in.	4·88 in.	2·54 in.
December	2·72	2·35	1·52	2·50	1·40	2·47
	1889.		1890.		1891.	
January	4·22	1·79	1·37	1·86	1·21	1·85
	<u>7·56 in.</u>	<u>6·64 in.</u>	<u>7·16 in.</u>	<u>6·84 in.</u>	<u>7·49 in.</u>	<u>6·86 in.</u>
Disease at Hort. Gardens... {	Mild.		Bad.		Mild.	

The above table shows that it is not a mere matter of moisture which settles the greater or less prevalence of the disease, but other conditions, such as accompanying heat or cold, will also influence it.

Generally the spores are plentifully produced about the beginning of the year, and the leaves have usually all dropped off by April. It is very noticeable how the leaves fall away from the lower ends of the branches, leaving only a small tuft of leaves at the top, which may be regarded as the expiring effort of nature to renew the foliage of which the tree is prematurely deprived.

HOSTS AND PARTS ATTACKED.

I have found the fungus in Victoria on the leaves of the peach and its smooth-skinned variety the nectarine, the plum, the apricot and the almond. It is most prevalent on the plum and peach and comparatively rare as yet on the apricot and almond. In other parts of the world the disease is found on other species of *Prunus*. In California it attacks the cherry in addition to the above, and in the old world it is found on the sloe or blackthorn (*Prunus spinosa*), and other species. Although this fungus has only been known elsewhere to attack the leaves, I had a specimen sent from Wangaratta in which the fruit was affected. It was very noticeable that only one side was attacked, and presented the appearance of a number of pimples or blisters of a brownish colour. The fungus was evidently not so far advanced as on the leaves, so that the conspicuous rusty colour was not so apparent.

In South Australia the disease has been found on the peach, plum, apricot and almond leaves, as well as on the *fruit* of the apricot. The latter specimen was kindly sent to me by J. G. O. Tepper, F.L.S., for determination, and he was naturally surprised to find the leaf-rust become a fruit-rust. It is rather peculiar that no previous record of such a comparatively common rust should be known on fruit outside of the Australian colonies, but it only shows what a glorious climate we have for luxuriant growth, that of fungi included, and it points to the grave danger of allowing fungus pests to run rampant, for they may attack

quite a variety of fruits here to which they were formerly strangers.

As might be anticipated, this fungus has its peculiarities of attack. In my own garden, for instance, the peach and plum trees were badly affected, while an apricot whose branches interlaced with an affected peach tree had not a speck upon it. In the Royal Horticultural Gardens, Burnley, apricot and almond trees are as yet unaffected, and in 1890-91 not even plums were attacked, only peaches. J. G. O. Tepper, of Adelaide, informs me that in his garden the apricots are very badly affected year after year, peaches to a slightly less extent, and a plum tree with the branches touching other diseased trees is wholly unaffected. In contrast to this, there is the case already mentioned where the peach trees were unaffected and the plum trees more or less attacked. No doubt the variety of the respective trees will have an important influence on the immunity from or liability to disease.

VARIETIES MOST AFFECTED.

In the Royal Horticultural Gardens, Burnley, where so many different varieties are grown, I was able, with the assistance of Mr. Neilson, to select some of those most affected. Kerr's Slip-stone, Royal George and Crimson George are very liable among peaches, and Darwin and Dante among nectarines. Seedling peaches are also badly attacked.

Plums such as Late Harvey and Imperial Ottoman were pretty bad, and it was very noticeable that all those provided with thorns, such as the French Cherry Plum, seemed to enjoy comparative immunity from the disease.

DISTRIBUTION.

This disease has a very wide distribution, possibly co-extensive with the cultivation of the peach and allied fruits. It has actually been found in Britain, France, Germany, Italy, Austria, Belgium, Switzerland, North America, Canary Islands, India, Cape Colony and Australia. As regards its local distribution in Victoria, it extends from the Murray to the sea—from Rutherglen in the north to Warrnambool in the south.

INVESTIGATIONS.

I have examined a large number of specimens this season from different districts and have found the fungus, as already stated, on peach, nectarine, plum, apricot and almond. I have also specimens from the Herbarium of the United States Department of Agriculture, through the courtesy of B. T. Galloway, Chief of the Division of Vegetable Pathology, and these may be taken as a starting point.

On the leaves of *Prunus americana*, the plum of North America (3rd Oct., 1889), there is nothing to be found but two-celled teleutospores, while on the leaves of another species of *Prunus* (28th Sept., 1889) there are a few uredospores, but the great majority are teleutospores. Fig. 1 shows (*a*) the uredospore which is yellowish-brown in colour, (*b*) paraphysis which is of a pale lemon-yellow colour, and (*c*) teleutospores which are of a dark brown, the lower equally so with the upper, but in many cases paler. There is no doubt but this fungus is *Puccinia pruni*, Pers. In the Victorian specimens the presence of two-celled teleutospores will settle the point that the fungus is not a *Uromyces*, and the teleutospores are common enough, so that it is a *Puccinia*. But if the peach leaf is examined in the summer season and even up to July in many cases, only one kind of spore will be found—the uredospore. And even on the plum leaf in the month of March I was unable to find a single teleutospore.

On the peach leaves sent from Queensland by Mr. Tryon I found both uredospores and teleutospores (figs. 2 and 3). The uredospores were of the normal shape and varying in size from 28 to 31 μ long \times 14 to 16 μ broad. The teleutospores were also normal, varying from 25 to 34 μ long \times 17 to 20 μ broad, and the pedicels were short and transparent. By gentle pressure the two cells of the teleutospore can be readily separated, and in fact they often fall asunder in the process of mounting. The upper cell seems to be more brittle than the lower, as it is often broken up under slight pressure, while the other usually remains intact. I have drawn a lower cell (fig. 2*c*) separated by gentle pressure,

and it looks so rounded at the point of junction with the upper cell that one might readily mistake it for an independent, unicellular, stalked spore.

It would appear, however, that on the continent of Europe the teleutospore form is the prevailing one, for De Bary* speaks of *Puccinia pruni* belonging to the *Micropuccinia*, as teleutospores only are known.

No doubt the absence of teleutospores helped to mislead Dr. Cooke in his determination, and such a case emphasises the necessity for continuous observation of many of these fungi on the spot, in order to determine accurately their affinities, for at certain seasons only the uredospores are present, as in this instance, or it may be that the teleutospores only are present as in the case of *Puccinia burchardiae* determined by Dr. Saccardo where I had to supplement the description with that of the uredospores.†

A few brief notes may now be given on each of the Victorian hosts mentioned, in order to show that it is the same fungus disease which affects them all. *Puccinia pruni*, Pers., has to be recorded as new to Victoria for the apricot.

Peach.—Leaf-rust on the peach has been very prevalent this season, and yet the teleutospores are comparatively rare in the specimens which I have examined even in the month of July. A number of leaves were examined from peach trees in my own garden, but no teleutospores were found, only uredospores (fig. 6). In one instance the uredospore had germinated on the leaf still attached to the tree as shown in fig. 5. On some peach leaves from the Royal Horticultural Gardens, teleutospores were found, but not in great quantity, along with uredospores. I have just examined (July 3rd) some leaves from young trees of Bidwell's Late, Improved China Flat, Red Ceylon, &c., and while there is abundance of uredospores there are no teleutospores. The pustules containing teleutospores and uredospores mixed may be readily

* Comp. Morph. and Biology of the Fungi, p. 285 (1887).

† Vict. Nat. x. 192 (1894).

recognised by the dark brown almost black appearance in contrast to the rusty-brown pustules containing uredospores alone.

Nectarine.—On the leaves of a nectarine (Dante) from the Royal Horticultural Gardens teleutospores were found, agreeing closely with those on peach (fig. 6) as well as on the variety called Darwin.

Plum.—On plum leaves from the Gardens, only comparatively few uredospores were found, while teleutospores were plentiful (fig. 7).

A specimen of plum leaf with rust upon it, plucked on May 19th, was sent from Hobart by Mr. Rodway, and both uredospores and teleutospores were found upon it (fig. 8).

Apricot.—The rust on the apricot leaf is still comparatively rare in Victoria. I am indebted for specimens to an indefatigable worker, Mr. G. H. Robinson, of Ardmona, who sent them as far back as June 23rd, 1894. The teleutospores were not numerous among the uredospores, and one is shown in fig. 9.

In Mr. Tepper's specimen on the fruit forwarded early in January, only uredospores were found (fig. 10). The skin of the apricot had small yellowish to brownish blotches over it, and the uredospores are seen to be of the normal type, but sometimes rather elongated, even attaining a length of 44μ . On the other hand, they are sometimes excessively shortened, and the extremes of length, 26 to 44μ , were met with in this one specimen. They are, however, in relatively small quantity, and I am inclined to think that the close-set, downy hairs interfered with their proper development. When a microscopic section of the skin is made, only a few uredospores are seen with difficulty among the hairs, attached to the matrix.

Almond.—As in the case of the apricot, the fungus is also very scarce as yet on the almond in Victoria. On June 17th of last year, Mr. Robinson found at Ardmona only a few leaves, and each with one pustule containing uredospores which are shown in fig. 11.

I had also specimens from Netherby in December, 1893, and the undersurface of the leaves had quite a rusty appearance, owing

to the numerous pustules, which contained teleutospores as well as uredospores (fig. 12). Curiously enough the almond leaves sent in June from Ardmona in the Goulburn Valley contained only uredospores and these sparingly, while almond leaves from Netherby in the extreme west of the Colony, but practically in the same degree of latitude, contained both uredospores and teleutospores in abundance.

After diligent search in the Royal Horticultural Gardens, Burnley, I cannot find any trace of the fungus on the almond leaves there, and nine different varieties are grown.

From a comparison of the uredospores and teleutospores on the above different species of *Prunus*, there can be no doubt of their identity or of their being *Puccinia pruni*, Pers.

Further, the summer-spores (uredospores) are produced in great profusion, commencing as a rule in December and January, succeeded by the winter-spores (teleutospores) in May and June, which represent with us the end of autumn and the beginning of winter. In the uredospores the apex is not perforated by a single germ-pore as in *Uromyces*, but there are at least two lateral germ-pores. The teleutospores as noted in the British species are apt to separate at the septum, so that numerous unicellular spores are often to be seen, which might easily on a cursory glance be mistaken for something else. Hitherto the teleutospores are to be found most plentifully on plum leaves in Victoria, and much more sparingly on the others.

GERMINATION OF SPORES.

Both uredospores and teleutospores have been kept for some time in a moist chamber and only uredospores have germinated. This is in keeping with what we already know of this fungus, that it belongs to the group *Hemipuccinia*, having uredospores and teleutospores, the latter only germinating after a period of rest. No nutritive solution was used to stimulate germination, only water (fig. 13).

There was an average temperature of from 10° to 12° C.

The fate of the teleutospores has not yet been traced. As showing the practical importance of studying the life-history of these

parasitic fungi and the utility of such knowledge to the grower, I cannot do better than quote from a letter recently received from Mr. George Quinn, Inspector under "The Vine, Fruit and Vegetable Protection Act," South Australia. He writes (May 28th, 1895):—"The disease (*Puccinia pruni*) has been very prevalent in our orchards in all parts of the Colony in the season just closing, and I am somewhat in doubt as to how its spores exist over the winter, for in orchards where the peach or plum trees have been thoroughly sprayed with Bordeaux Mixture, with excellent results, as far as the 'curl leaf' is concerned on the former, and I am perplexed as to where the spores find refuge until the autumn when the pustules begin to show on the foliage of the trees. Do you think it possible for the spores which have fallen either before or with the diseased leaves to be ploughed into the soil and then be turned up again with the summer cultivator to rise with the dust among the foliage, and, the conditions being suitable, germinate? Do you think the spores of the various parasitic fungi which injure our fruits would lose their vitality completely if ploughed beneath the soil for a winter? Would they not *keep*, like the seeds of some more highly organized vegetables, for a considerable time?"

To answer the above question, I am testing during the forthcoming season, 1st, if the uredospores retain their vitality and germinating power during the winter, both when lying on the surface of the ground and when buried to a depth of four or five inches; 2nd, at what time teleutospores are capable of germination and how they are affected by being buried in the ground four or five inches deep; and 3rd, if they can produce the disease in an otherwise healthy tree. The answer to these questions will fill up gaps in our knowledge concerning the life-history of this parasite and enable us the more effectually to cope with it.

That the peach leaf rust of Australia is not due to a *Uromyces* should now be conclusively proved, because of the two-celled teleutospores and the uredospores having a transverse band of germ-pores instead of a single apical germ-pore.

TREATMENT.

The treatment must be preventive, and spraying with ammoniacal solution of copper carbonate and modified eau celeste has been found successful in the United States. The improved form of Bordeaux Mixture, as given in Guides to Growers, No. 15 (see Literature at end), has been found effectual with us, and since the lower surface of the leaves is affected, the spraying should be specially directed there.

There is another preventive measure which should never be neglected, and that is the burning as far as possible of the affected leaves in order to destroy the winter spores. So important and so generally applicable is this advice, that the remarks of the late Baron von Thuemen on this particular disease may be quoted in full:—"The surest and most effectual means of combating this rust, as well as other rust fungi, is to destroy the resting-spore generation as far as possible. The purpose of the special spore appearing in the autumn is to tide the species over the winter. On the leaves lying on the ground, even if they are decayed and decomposed, the spore-clusters remain for the most part completely safe. So when the trees put forth their young leaves next year they are infected afresh from the soil, by means of the spores present there in unlimited quantities, on little bits of the leaves hardly recognisable. These spores, on account of their tenacity of life, have received the name of 'resting-spores.' Hence the imperative necessity for the fruit grower to destroy the leaves covered with heaps of spores, in order to prevent fresh infection. This is best done in the autumn when all the leaves have fallen from the tree, and they may then be carefully collected and burnt. Or if this is impracticable, the land under the trees should be deeply dug so that all affected leaves may be buried deeply in the soil, where they can do no further mischief."

Since writing this paper I have seen the Report of Professor Scribner* for 1887 on "Leaf Rust of the Cherry, Peach, Plum,

* Report of the Commissioner of Agriculture, U.S.A., for 1887, pp. 353 to 355.

&c.—*Puccinia pruni-spinosæ*, Pers.," and have incorporated some of his references in the literature of the subject. There are several points in it worthy of comment, as showing the different behaviour of the same fungus under different conditions of existence. After noting that the fungus has been described under several different names, he remarks:—"Some confusion has probably arisen from the fact that the uredo stage alone occurs upon the peach and from the resemblance of the uredospores to the teleutospores of *Uromyces*." Both the uredo-stage and teleuto-stage, as we have seen, occur upon the peach in Australia, nevertheless the latter is comparatively rare and has undoubtedly led to misunderstanding of the true nature of the fungus from the absence of two-celled teleutospores. The uredospores are certainly suggestive of *Uromyces* on a superficial view, but their germination, not by a single apical pore, but by a band behind the apex, excludes the idea.

Again he states:—"The uredospores may or may not be present on the plum, but on the specimens examined a few have been found in all cases mingled with the teleutospores." In specimens of plum leaves described by me in Bulletin xiv. of the Victorian Department of Agriculture in March, 1891, only uredospores were present at that time, while on specimens examined by Professor De Bary only teleutospores were present and no uredospores.

Again he remarks:—"Teleutospores have never yet been found upon the peach, and it is probable that they do not occur upon it at all, since specimens gathered in Texas as late as December 26th failed to show any."

It is rather a strange and striking fact that teleutospores which are commonly regarded as winter spores should occur upon the peach in a climate such as ours and not in America.

To show the thorough agreement between American specimens of *Puccinia pruni*, Pers., and Australian so-called *Uromyces amygdali*, Cooke, I have reproduced some of Professor Scribner's drawings for comparison (fig. 14). They prove conclusively the identity of the two forms and disprove, if such were needed, and in spite of Dr. Cooke's pertinacity, the *Uromyces*-character of

the form under consideration. His *Uromyces amygdali* is simply the uredo-stage of *Puccinia pruni*.

DESCRIPTION.

It only remains now to conclude with a description of the fungus as found in Australia.

Uredospores.—Sori hypophyllous, small, light brown to rusty brown, roundish, scattered but grouped in patches, often confluent, soon naked, pulverulent, seated on yellow spots corresponding to those on upper surface.

Uredospores variable in form, from elongated-ovate to almond-shaped, usually shortly stalked, but sometimes $22\ \mu$ in length, closely echinulate, yellowish, apex yellowish-brown, thickened, with spines less prominent, bluntly conical or rounded, with at least two opposite germ-pores situated just behind thickened apex, $26-44 \times 12-20\ \mu$, intermixed with numerous capitate, pale yellow, long-stalked paraphyses, sometimes attaining a length of $60\ \mu$.

Teleutospores.—Sori scattered or confluent, isolated or in groups, punctulate, pulverulent, seal-brown, known from the other by their dark almost black appearance.

Teleutospores composed of two spherical cells, apparently flattened at their junction, lower usually smaller and paler than upper, but sometimes similar in size and colour, sharply constricted in the middle and cells readily separating. Epispore uniformly thick, dark brown, thickly studded with short stout spikes, $25-37 \times 17-21\ \mu$. Pedicels short, hyaline, deciduous or persistent, from 4 to $8\ \mu$ long.

On leaves of peach, nectarine, plum, apricot and almond, and occasionally on fruits of peach and apricot: December to June. New South Wales, Victoria, Queensland, S. Australia and Tasmania.

SYNONYMS.

Puccinia pruni-spinosæ, Pers. (1797).

Uredo prunastri, DC. (1805).

Puccinia prunorum, Link (1825).

Uromyces prunorum, Fekl. (1869).

Uromyces amygdali, Pass., (1873), and Cooke (1878-1882).

Uromyces prunorum, var. *amygdali*, Vize (1878).

REFERENCES AND LITERATURE.

COOKE—Rust, Smut, Mildew and Mould. 1st Ed. p. 201, 1865.

Puccinia prunorum, Lk., or plum tree brand, described as common in Britain on plum trees.

FUCKEL—Symbolæ Mycologicæ, p. 50, 1869.

PECK—Twenty-fifth Report of the Regents of the University of the State of New York, p. 116, 1873.

Leaves of wild cherry, *Prunus serotina*, Ehrh. This species seems to be rare.

VIZE—Californian Fungi. Grevillea, Vol. vii. p. 12, 1878.

Uromyces prunorum, Lk., var. *amygdali*, on peach leaves.

FRANK—Die Krankheiten der Pflanzen, p. 468, 1881.

Puccinia prunorum, Link, on leaves of *Prunus persica*, *P. domestica*, *P. insititia*, *P. armeniaca* and *P. amygdalus*.

KALCHBRENNER—Fungi Macowaniani. Grevillea, Vol. xi. p. 19, 1882.

Uromyces prunorum, v. *amygdali* on *Prunus persica*.

COOKE—Australian Fungi. Grevillea, Vol. xi., p. 97, 1883, *Puccinia prunorum*, Link, Victoria.

FARLOW—Notes on some species in the 3rd and 11th centuries of Ellis's North American Fungi. Proc. Am. Acad. Arts and Sci. Boston, xviii. p. 82, 1883.

"As far as my experience goes, the uredospores of *P. prunorum*, Lk., are much less common near Cambridge than the teleutospores, but in the Southern States they are common."

WINTER—Die Pilze, Vol. i. p. 193, 1884.

Teleutospore of *Puccinia pruni*, figured after Corda at p. 136.

BURRILL—Parasitic Fungi of Illinois. Part i. Uredineae in Bull. Illinois State Laboratory, ii. p. 177, 1885.

SORAUER—Handbuch der Pflanzenkrankheiten, Vol. ii. p. 226, 1886.

Puccinia pruni-spinosæ, Pers., on *Prunus persica*, *P. armeniaca*, *P. spinosa*, *P. insititia* and *P. domestica*.

TRELEASE—Preliminary list of the parasitic fungi of Wisconsin. Trans. Wisconsin Acad. Sci. Arts. vi. p. 24, 1886.

Uredo- and teleutospores recorded on leaves of seedling *Prunus americana*, Marsh, as well as on older leaves of same species and of *P. virginiana*.

DE BARY—Fungi, Mycetoza and Bacteria, p. 285, 1887.

Puccinia pruni given as belonging to *Micropuccinia*, in which only teleutospores are known.

ARTHUR—Bulletin of Iowa Agricultural College, p. 159, 1887.

SCRIBNER—Report of the Commissioner of Agriculture, U.S.A., for 1887—Section of Vegetable Pathology, pp. 353 to 355.

Description and drawings of *Puccinia pruni-spinosæ*, Pers.—Leaf-rust of the cherry, peach, plum, &c.

DIETEL—Verzeichnis sämtlicher Uredineen nach Familien ihrer Nährpflanzen geordnet. Leipzig, p. 31, 1888.

Puccinia pruni-spinosæ, Pers., on *Prunus persica*, *P. spinosa*, *P. armeniaca*, *P. insititia*, *P. domestica*, *P. virginiana*, *P. americana* and *P. serotina*.

SACCARDO—Sylloge Fungorum, Vol. vii. p. 648, 1888.

Puccinia pruni, Pers., described and Synonyms given as *Uromyces amygdali*, Pass., in Erb. Critt. Ital., &c. On *Prunus amygdalus*, *P. domestica*, *P. armeniaca* and *P. persica*.

VON THUEMEN—Die Pilze des Aprikosenbaumes (*Armeniaca vulgaris*, Lam.)—Eine Monographie. Klosterneuberg, pp. 8 and 9, 1888.

Puccinia prunorum, Lk., on apricots and plums, the uredo- or stylospore form occurring in the height of summer, and, some time after, the teleutospores.

BAILEY—Second Supplement to Synopsis of the Queensland Flora, p. 126, 1888.

Uromyces amygdali, Cooke, on almond and peach leaves.

HALSTED—Bulletin Iowa Agricultural College, 1888.

FARLEY AND SEYMOUR—A provisional Host-Index of the Fungi of the United States. Vol. i. p. 32, &c., 1888, and Vol. iii. p. 197, 1890.

Synonymy and Hosts of *Puccinia pruni* given.

PLOWRIGHT—British Uredineæ and Ustilagineæ, p. 192, 1889.

Puccinia pruni, Pers., on *Prunus spinosa*, *P. domestica*, and *Rhamnus catharticus*.

TRYON—Report on Insect and Fungus Pests, Brisbane, p. 97, &c., 1889.

Uromyces amygdali, Cooke, a new fungus determined by Dr. Cooke, on peach and almond leaves, Queensland.

BRUNK—Bordeaux Mixture for the Plum Leaf-blight. Journal of Mycology, p. 38, 1889.

Peach and plum trees affected with *Puccinia pruni-spinosæ*.

ANNUAL REPORT—State Board of Horticulture of California for 1889.

EARLE—Experiments with Fungicides for Plant Diseases. Bull. ii. Veg. Path. Sec. U.S.A., p. 38, 1890.

Notices injury to peach and plum leaves from Bordeaux Mixture applied for rust: *Puccinia pruni*, Pers.

ANDERSON—Notes on certain Uredineæ and Ustilagineæ. Journal of Mycology, p. 125, 1890.

Uromyces amygdali, Cooke, agrees in every particular with *Puccinia pruni*, Pers., on peach and plum hosts in the United States.

COBB—Peach-rust in Orchards. Ag. Gaz. N.S.W. Vol. i. Pt. 1, p. 93, 1890.

Uromyces amygdali, Cooke, identical with *Puccinia pruni*, Pers.

McALPINE—Report on Peach and Plum-leaf Rust (*Puccinia pruni*, Pers.). Bull. xiv. Dept. of Ag. Victoria, pp. 138-147, 2 Plates, 1891.

Nature of fungus and remedies given.

COBB—Remedies for Peach-rust. Ag. Gaz. N.S.W. Vol. ii. Pt. 3, p. 157, 1891.

Burning leaves, spraying and application of potash manures recommended.

COOKE—Handbook of Australian Fungi, p. 331, 1892.

Uromyces amygdali, Cooke, in Rav. Fung. Amer.; Pass. in Erb. Critt. Ital., on Peach and Almond leaves, Queensland, Victoria, New South Wales.

THOMPSON—A Handbook to the Insect Pests of Farm and Orchard. Depart. of Ag. Tasmania, Bull. i., pp. 29 and 30, 1892.

Description and treatment given of *Puccinia pruni*.

GALLOWAY—Report of the Chief of the Division of Vegetable Pathology for 1892: U.S. Dept. of Ag. p. 232.

Puccinia pruni-spinosæ on peach, nectarine, apricot, cherry, almond and plum.

SMITH—Field Notes, 1891, in Journal of Mycology, p. 92, 1892.

Uromyces pruni-spinosæ, Pers., appears to prefer thickly planted nursery stock.

BAILEY—A review of the Fungus-blight which have been observed to injure living vegetation in the Colony of Queensland. Report of Fourth Meeting of Aust. Assoc. Adv. Science, p. 400, 1892.

Uromyces amygdali, Cooke, very abundant of late years on the foliage of the peach and allied trees in Southern Queensland.

WEED—Fungi and Fungicides. New York, p. 65, 1894.

Plum-leaf Rust—*Puccinia pruni-spinosæ*. Only mentioned on plum leaves.

PIERCE—Prune Rust: Journal of Mycology, vii., No. 4, p. 354, 1894. Affecting prune, plum, peach, nectarine, apricot, cherry and almond.

Ammoniacal copper carbonate effectual for treatment.

McALPINE—Spraying for Fungus Diseases. Guides to Growers, No. 15. Dept. of Agriculture, Victoria, p. 8, 1894.

Improved form of Bordeaux Mixture a preventive for this rust.

EXPLANATION OF FIGURES.

(Magnified 600 dia. except fig. 14.)

Plate XXXI. (lower division of Plate).

Fig. 1.—*Puccinia pruni*, Pers., from *Prunus* sp., United States.

a, uredospore yellowish-brown, closely echinulate; *b*, paraphysis, pale lemon yellow and long-stalked; *c*, deep dark brown teleutospores studded with short bluntish spines.

Fig. 2.—Uredospores and teleutospores on peach leaf from Queensland—June.

a, uredospore, yellowish-brown, average twice as long as broad; *b*, teleutospore, dark brown, but somewhat translucent; *c*, lower cell of teleutospore detached, showing rounded top.

Fig. 3.—Uredospores and teleutospores of same, mounted dry.

a, group of uredospores, individuals selected from different parts of field; *b*, group of teleutospores found together.

Plate XXXII.

Fig. 4.—Uredospores (*a*) with persistent pedicels and paraphyses (*b*) from peach leaf in own garden—June.

Fig. 5.—Germinating uredospore from peach leaf in own garden—June. There are two germ-tubes, but one is in abeyance.



- Fig. 6.—Teleutospore from nectarine—June.
Fig. 7.—Uredospores (*a*) and teleutospores (*b*) from plum leaf—May.
Fig. 8.—Uredospores (*a*) and teleutospores (*b*) from plum leaf, Tasmania—May.
Fig. 9.—Teleutospore from apricot—June—showing top cell detached and entire.

Plate XXXIII.

- Fig. 10.—Group of uredospores from skin of apricot—showing the widest extremes in length.
Fig. 11.—Uredospores from almond leaf—June.
Fig. 12.—Uredospores (*a*) and teleutospores (*b*) from almond leaf—December.
Fig. 13.—Germinating uredospores from plum leaf, Tasmania—plucked May 19th.
a, after nearly 5 days (4 days 21 hours) in moist chamber; *b*, contents of germ tube vacuolated, and contents of spore turbid; *c*, contents of spore as usual, but contents of tube with minute particles aggregated at intervals; *d*, germ-tube curving upon itself.
Fig. 14.—Uredospores from peach and plum, and teleutospores from plum (after F. L. Scribner).
a, uredospores from peach, stalkless and echinulate; *b*, germinating uredospore from plum, with germ-tube on one side; *c*, teleutospores from plum in surface view showing markings; *d*, the same in optical section.